**RICHARD C. SLADE & ASSOCIATES LLC**
**CONSULTING GROUNDWATER GEOLOGISTS**

**MEMORANDUM**

September 12, 2017

To: Mr. Jack Locey, P.E., President
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Sent via email (locey@brce.com)

Job No. 154-MNE02

From: Chris Wick, Anthony Hicke and Richard C. Slade
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Re: Results of Hydrogeologic Study and Water Well Feasibility
For the Anderson Valley Community Services District
Boonville Area, Mendocino County, California

## INTRODUCTION

Provided herein are the key findings, conclusions, and preliminary recommendations regarding our hydrogeologic study and water well feasibility project for possible new water-supply wells for the Anderson Valley Community Services District (AVCSD) in the Boonville area of Mendocino County, California. Figure 1, "Location Map," shows the boundaries of the four proposed AVCSD water service areas on a USGS topographic map that is comprised of several quadrangles of the area. Boundaries for these four water service areas proposed by AVCSD were provided to RCS by Brelje & Race Consulting Engineers (BRCE), of Santa Rosa, California (the project engineer). Also shown on Figure 1 are the approximate locations of numerous privately-owned water wells in the Boonville area and the locations of three nested groundwater monitoring wells owned by Mendocino County Water Agency (MCWA).

RCS understands that the AVCSD is in need of developing groundwater resources in useable quantities and of acceptable quality for public-supply purposes for the proposed project water service areas shown on Figure 1. AVCSD reportedly desires a total combined pumping rate on the order of 90 to 120 gallons per minute (gpm), depending on the proposed water service area. We further understand that the source of this water could be from an existing water well, or from new wells yet to be drilled and constructed within the project service areas, or via an exchange/purchase agreement with an owner of an existing, privately-owned water well in the area.

Thus, for the purposes of this hydrogeologic study and water well feasibility project, RCS has performed a hydrogeologic evaluation of the Boonville area and provided our preliminary recommendations for areas within the proposed AVCSD water service areas that may be viable for developing groundwater resources in terms of both production capabilities and water quality. BRCE has proposed to perform pumping tests in those existing, private wells to help better

**MEMORANDUM**

understand the possible future normal operational rates of wells located in areas deemed feasible to develop groundwater resources. BRCE estimates that a minimum of 5 water wells may be needed to provide the water demands for the proposed AVCSD water service areas.

## SITE CONDITIONS

Figure 2, "Aerial Photograph Map," shows the proposed AVCSD water service areas and those well locations shown on Figure 1 on an aerial photograph of the Boonville area (the date of this imagery is June 2014); this aerial photograph was obtained from publicly-available imagery from the United States Geological Survey's (USGS) EarthExplorer website (https://earthexplorer.usgs.gov/). From our review of the topographic data and aerial imagery for the region, the following key items were noted (refer to Figures 1 and 2):

a. Boonville is accessed directly via Highway 128, and the majority of the residential and commercial developments within the community are located immediately east and west of Highway 128. Boonville is located roughly 6 miles southeast of Philo and 13 miles southwest of Ukiah.

b. Boonville and its environs are generally located within Sections 1, 2, 3, 11, and 12, Township 13 North, Range 14 West, Mt. Diablo Baseline & Meridian (MDB&M), and Sections 34 and 35, Township 14 North, Range 14 West, MDB&M.

c. Topographically, Boonville is situated in southwestern portion of the Anderson Valley, which is a long, narrow inland valley in the Coast Ranges of Mendocino County. Anderson Valley is generally oriented in a northwest-southeast direction. From the topographic contours shown on Figure 1, and as observed on aerial photographs of the area (see Figure 2), Boonville is bounded by foothills to the east, south, and west. As such, the majority of the Boonville area and its environs are relatively flat and lie along the floor of the Anderson Valley, whereas the foothill areas to the east, south, and west are topographically higher and steeper. Foothill elevations around the Boonville area generally range from ±400 ft to ±1,600 feet above mean sea level (ft msl), whereas the valley floor sits at elevations between ±350 ft and ±450 ft msl.

d. Anderson Creek, as shown on Figure 1, is an ephemeral creek that emanates from the foothills to the southeast of Boonville and drains towards Boonville, and is sub-parallel to Highway 128, along the central portion of Anderson Valley. Anderson Creek flows to the northwest and is a tributary to the Navarro Creek in the Philo area to the northwest.

e. Much of the Boonville area is occupied by single-family residences and small commercial developments. Vineyards were also observed (via aerial photography) to be primarily located along the east side of Highway 128, and in the southern end of Anderson Valley. The foothill areas to the east and west of Boonville are generally undeveloped and consist of naturally vegetated and/or wooded areas.

## LOCAL GEOLOGICAL CONDITIONS

Figure 3, "Geologic Map," illustrates the types, lateral extents, and boundaries between the various earth materials mapped at ground surface in the region by others, as published by the California Division of Mines and Geology (CDMG 1960 and 1982). Specifically, Figure 3 has

**MEMORANDUM**

been adapted from the results of regional geologic field mapping of the Ukiah and Santa Rosa quadrangles, as published by the CDMG in 1960 (Jennings, C., and Strand, R.) and 1982 (Wagner, D., and Bortugno, E.), respectively. Key earth materials mapped at ground surface in the area, as shown on Figure 3 from geologically youngest to oldest, include the following:

a. Alluvium (map symbol Qal). These materials, which are Holocene in geologic age, generally consist of unconsolidated alluvial fan and/or fluvial deposits, including active steam channel deposits. These sediments consist of layers and lenses of sand, silt, gravel, and clay, and were derived from the erosion of nearby hills, and were transported to their current locations by fluvial processes (i.e., they moved to their current locations via water). In the Boonville area, these alluvial-type deposits generally exist along the Anderson Creek in the central portion of the Anderson Valley. On Figure 3, these materials are shown in a pale yellow color. Exposures of these alluvial-type deposits are exposed at ground surface in the northern and central portions of the proposed AVSCD service areas.

b. Non-marine terrace deposits (map symbol Qt). These materials, which are of Pleistocene geologic age, consist of unconsolidated sand, silt, gravel, and clay deposited on stream-cut surfaces; alluvial flood plain and fan deposits tend to be brown and yellow in color, while lacustrine deposits tend to be blue-grey and green. On Figure 3, these materials are shown in a bright yellow color. Similar to the alluvium deposits described above, terrace deposits are also shown to exist along Anderson Creek and at the base of the foothills in the Boonville area. These terrace deposits occur at ground surface, across most of the proposed AVCSD water service areas.

c. Cache Formation (map symbol QP). These materials, which are Plio-Pleistocene in geologic age, consist of slightly to moderately consolidated lacustrine and fluvial deposits that both border and underlie the local valley. These deposits are comprised by fine-grained to pebbly sandstone, cobble conglomerate, silt, clay, and local tuff (CDMG 1960 and CDMG 1982). This unit has also been called “continental basin deposits” (Farrar 1986), “Anderson Valley alluvium” (Manson 1984), and “undifferentiated Plio-Pleistocene deposits” (DPW/DWR 1956). These deposits are shown on Figure 3 to be exposed at ground surface in the hillsides to the north and northwest of the Boonville area.

d. Bedrock. Local bedrock consists of sedimentary and metasedimentary units of Tertiary to Cretaceous geologic age rocks, with discrete masses of serpentinite commonly found within and along the boundaries of the Franciscan Complex. In the Mendocino County region, the Franciscan Complex is subdivided into the two northwest-trending subparallel belts names the “Coastal belt” and “Central belt” (Farrar 1986), and in the Boonville area, only the “Coastal belt” Franciscan Complex is exposed at ground surface. The “Coastal belt” Franciscan Complex is labeled as “Undivided Cretaceous Marine” (map symbol K and shown in pale green color on Figure 3, CDMG 1960) or “Coastal Belt Franciscan” (map symbol TKf and shown in dark green color on Figure 3, CDMG 1982). These Coastal Belt Franciscan rock types consist of consolidated marine sandstone, shale and conglomerate (CDMG 1982) and are primarily exposed in the hillsides surrounding the Boonville area. Other Franciscan-type Complex rocks (map symbol KJf, and shown in a dark green horizontal pattern on Figure 3) are similar well-consolidated, thick-bedded sandstone, shale, and conglomerate rocks that contain minor limestone, greenstone, and chert; parts of the Complex are mélange and consist of chaotic mixtures of fragmented rock masses in a sheared shaly matrix (as deoted by horizontal patterns on Figure 3). The various sedimentary rock types assigned to the Franciscan Complex represent the bedrock in the region.

Because of their high degree of consolidation, cementation, and/or crystalline nature, only minor amounts of groundwater can be stored in the fractures and joints in these rocks; the primary porosity is virtually non-existent. However, due to the intense geologic forces (i.e., tectonic activity) to which the rocks have been subjected over geologic time, numerous fractures, joints and shear planes have developed in the rocks over time. Groundwater will only occur in these fractures and joints in the bedrock strata.

Therefore, the amount of water available to a well constructed within rocks of the Franciscan Complex is highly dependent on such factors as the size, number, frequency of occurrence, openness, lateral continuity and degree of interconnection of the joints and fractures encountered at a specific drill site. Fracture systems within the Franciscan Complex are highly sporadic in regard to location, depth, and lateral continuity. Hence, it is impossible to predict the location of such water-bearing fractures within these rocks in advance of drilling. In addition to its limited ability to provide sustainable yields of groundwater to wells, this group of rocks is also known to frequently provide groundwater that has poor water quality. As a result, the Franciscan Complex is not considered to be a viable source of groundwater for the AVCSD.

## LOCAL HYDROGEOLOGICAL CONDITIONS

*Potentially Water-Bearing Materials*

The principal water-bearing materials for the Boonville area are represented by the unconsolidated alluvium, stream channel, and terrace deposits. A secondary source of groundwater might also be the eroded Plio-Pleistocene non-marine deposits of the Cache Formation, the continental basin deposits, or the undifferentiated Plio-Pleistocene sediments, depending on which reference is used for the nomenclature. These units are considered to comprise the “valley fill,” and they directly overlie the Franciscan Complex, which as discussed above, comprises the regional bedrock. In general, alluvium and stream channel deposits in the Anderson Valley region are reported to be no more than 20 to 40 feet thick; terrace deposits are reported to range from 5 ft to perhaps as much as 150 feet thick near Boonville (DPW/DWR 1956). Alluvial materials were derived mostly from Franciscan rocks, but reworked materials from both the Cache Formation and terrace deposits may also be included (Farrar 1986).

The Cache Formation comprises the oldest geologic materials within the area mapped by others as “valley fill” and was deposited directly on top of the Franciscan Complex in structural basins during late Pliocene and Pleistocene ages. Sediments comprising the Cache Formation were eroded from the older Franciscan rocks and subsequently deposited as alluvial fans around the valley margins. The central portion of the Anderson Valley was partly occupied by a lake around which deltas were built by inflowing braided streams (Farrar 1986). These sedimentary processes left behind a complex distribution of gravel, sand, silt, and clay. The high clay

**MEMORANDUM**

content reported in driller's logs for these deposits (particularly from the former lake) tended to result in interbedding of permeable and impermeable units, thus creating confined conditions (Farrar 1986). The reported thickness for these Plio-Pleistocene deposits is in excess of 200 ft in the vicinity of Philo, but deformation and erosion have caused the remnants of the formation to be discontinuous (DPW/DWR 1956). Only small portions of the Cache Formation are shown on Figure 3 to exist north of the Boonville area.

RCS geologists also reviewed electric logs and geologic logs for three nested groundwater monitoring wells that were drilled and constructed for the Mendocino County Water Agency (MCWA) between May and June 2002; these logs were acquired by BRCE and provided to RCS for review. The locations for the three MCWA nested monitoring wells (listed as "AV-1," "AV-2," and "AV-3") are shown on Figures 1 through 3. Each of the pilot boreholes were drilled by Spectrum Exploration, Inc. (SPI) and logged by a geologist from the Geology and Groundwater Section of the California Department of Water Resources (DWR), Central District. Overall, our review of these geologic logs revealed the following with rergard to the depth of the potential water-bearing sediments at each site:

- Well AV-1: Undifferentiated alluvial sediments and/or terrace deposits were reported to a depth of 80 ft below ground surface (bgs). Between 80 ft and the total drilled depth of 201.5 ft bgs, interbedded layers of shale, sandstone, and greywacke were observed by the geologist. These latter material represent fine-grained sedimentary bedrock of the Franciscan Complex.
- Well AV-2: Undifferentiated alluvial sediments and/or terrace deposits were reported from ground surface and a depth of 120 ft bgs. Dark greenish grey to bluish gray sediments were noted between the depths of 45 ft and 120 ft bgs. This lithologic change in color could indicate the presence of either lacustrine terrace deposits and/or deposits of the Cache Formation (described above). Sandstone, greywacke, and shale (i.e., bedrock of the Franciscan Complex) were observed to extend from a depth of 120 ft to the total drilled depth of 200.5 ft bgs.
- Well AV-3: Undifferentiated alluvial sediments and/or terrace deposits were reported to a depth of 207 ft bgs. Several layers of "blue clay" and/or "greenish-gray clay" were noted between the depths of 30 ft and 125 ft bgs, possibly indicating layers of lacustrine-type deposits and/or deposits of the Cache Formation between those depths. Sandstone, greywacke, and shale (assigned to the Franciscan Complex) were logged between the depths of 125 ft and the total drilled depth of 261 ft bgs.

Based on our interpretation of these geologic logs, its appears that potentially water-bearing alluvial deposits, stream channel deposits, and/or terrace-type deposits are thicker in the central portion of the Anderson Valley and along Anderson Valley Creek, and tend to thin out along the margins of the valley, closer to the hillsides.

*Potentially Nonwater-Bearing Rocks*

This category includes the geologically older and fine-grained sedimentary and/or crystalline rocks of the Franciscan Complex. These potentially nonwater-bearing rocks are exposed in the hillsides encompassing Anderson Valley, and would also directly underlie the alluvium, the terrace deposits, and/or Cache Formation materials that comprise the valley fill in the Boonville area. In essence, these Franciscan Complex rocks are well-cemented and well-lithified, and

**MEMORANDUM**

have an overall low permeability. Occasionally, localized conditions can allow for small quantities of groundwater to exist in these rocks wherever they may be sufficiently fractured or are relatively more coarse-grained. However, even in areas with such potentially favorable conditions, well yields are often only a few gpm in these rocks, and the water quality can be marginal to poor in terms of total dissolved solids concentrations, and other mineralogical constituents.

*Geologic Structure*

Major geologic structures depicted on geologic maps of Mendocino County show a predominant north to northwest trend which is consistent with that of the local topographic features and stream courses. The main axis of Anderson Valley follows this structural trend which is oriented subparallel to both the San Andreas fault (located about 12 miles southwest of the valley) and the Mayacamas fault zone (about 10 miles northeast of the Boonville area). Both the San Andreas and Mayacamas faults consist of active zones of subparallel breaks with right-lateral displacement. In addition, numerous faults of lesser displacement or with more obscure surface rupture exist throughout the County (Farrar 1986). Only the major faults which can be identified at the surface are depicted on regional geologic maps. Such faults do not appear in the mapped area as shown on Figure 3, but Anderson Valley comprises the northwest extension of major subparallel faults to the southeast (CDMG 1960 and 1982). The alluviated valleys of Mendocino County are structural basins, created by oblique pull-apart extensions along subparallel fault segments, which causes the intervening block to downdrop. Sedimentation infills the basin from the beginning of its formation and is still ongoing, concurrent with any further downdropping of the affected structural block. The thickness of the subsequent "valley fill" is dependent on the size of the block and the eventual amount of downdropping.

The possible impacts of these faults on groundwater availability in the region are unknown due to an absence of requisite data. Faults can serve to increase the number and frequency of fracturing in the local sedimentary rocks. If such fractures occurred, it would tend to increase the amount of open area in the rock fractures which, in turn, could increase the ability of the local sedimentary rocks to store groundwater. It is unknown if these faults are barriers to groundwater flow.

Please note: it is neither the purpose, nor within the Scope of Hydrogeologic Services for this project, to assess the potential seismicity or activity of any faults that may occur in the region.

## LOCAL GROUNDWATER BASIN

The California Department of Water Resources (DWR) prepared an early report (DWR 1975) to summarize "the known technical information on groundwater basins" on a State-wide basis. That report provided summaries of data for nearly 250 groundwater basins in the State, along with small-scale maps illustrating the locations and approximate boundaries of these basins. Those maps identified the important water-bearing formations in each groundwater basin in the State using published geologic maps and hydrogeological conditions. Basin locations, areal extents and basin boundaries were selected principally on the ability of the local earth materials to yield groundwater to wells.

Subsequently, DWR prepared its Bulletin 118-Update 2003 Report (DWR 2003), which includes numerous maps and tables to now identify approximately 515 groundwater basins in the State. Review of this Update 2003 Report (DWR 2003) reveals that the "Anderson Valley" groundwater basin represents one of several main groundwater basins identified by DWR in Mendocino

**MEMORANDUM**

County. The Anderson Valley Groundwater Basin (Groundwater Basin Number 1-19) has an approximate surface area of 7.7 square miles. Figure 4, "DWR Groundwater Basin Map," illustrates the location and areal extent of the Anderson Valley Groundwater Basin as identified by DWR (2003); the location of the proposed AVCSD water service areas are also shown for comparison. The DWR report defines the water-bearing materials in the Anderson Valley Basin to be the recent alluvium, stream channel, and terrace deposits along the floor of the Anderson Valley. The Franciscan Complex that underlies those alluvial-type depoists is considered to be nonwater-bearing. Based on publicly-available GIS boundary files for these groundwater basins, it appears that almost the entirety of the proposed AVCSD water service areas overlie the local groundwater basin. The DWR report also estimated an average specific yield of about 5.5% for the earth materials in the Anderson Valley Groundwater Basin. A total useable groundwater storage capacity for the Anderson Valley Basin was reported to be on the order of 47,000 acre feet (AF); however, the 2003-dated DWR report did not state whether or not this storage capacity was calculated solely for the alluvial sediments (including the terrace deposits), or if it also included the groundwater in storage in the Franciscan Complex rocks that underlie the alluvial materials along the floor of Anderson Valley, even though they are considered to be "essentially" nonwater-bearing.

In June 2014, the California Statewide Groundwater Elevation Monitoring (CASGEM) program introduced "Basin Prioritization" for the ±515 groundwater basins in the State. This CASGEM Basin Prioritization is a statewide ranking of groundwater basin importance that incorporates groundwater reliance and focuses on basins producing greater than 90% of California's annual groundwater (DWR 2014). The Anderson Valley Groundwater Basin has a basin ranking of "very low."

## DWR WELL RESEARCH

In order to better understand the historic water well drilling that has occurred in the Boonville area, BRCE obtained several "Well Completion Reports" (i.e., driller's logs) from the Division of Drinking Water – Mendocino District (DDW) for water wells in and around the Boonville area. From its efforts, BRCE received driller's logs for more than 100 wells historically drilled in the Boonville area. BRCE initially evaluated each of those driller's logs and culled those wells that had reported well "yields" of 20 gpm or greater, per "testing data" listed on those logs. Note that the driller-reported flow rate was the sole criterion used to cull the logs. The reported flow test method (via a pump, via airlifting, or via a bailer) was not considered. Of the more than 100 driller's logs received for the Boonville area, approximately 36 of those wells were reported to have well yields of 20 gpm or greater. Copies of those 36 driller's logs and data on the parcels on which those wells were drilled and constructed were provided to RCS to be further evaluated. Each of these well locations was then plotted on a base map of the Boonville area; the approximate location for each well was based on the central portion of each parcel; the RCS-plotted well locations are therefore approximate only. Figure 1 shows the approximate locations of the private wells within the proposed AVCSD water service areas, as plotted by RCS. A few of these private wells were plotted outside the proposed AVCSD water service areas.

The following provides a general summary of key information gleaned from our review of those BRCE-indentified private wells:

**MEMORANDUM**

a. Drilling Method. Drilling methods for the wells generally included direct air rotary and direct mud rotary. Two wells were reportedly drilled via bucket auger drilling. Of the 36 wells shown on Figure 1, many of the more successful wells (in terms of their reported airlift flow rates) are reported to have been drilled by the direct air rotary drilling method.

b. Well Casing Material. A majority of these private wells were constructed using PVC casing, whereas only a few wells were reported to be provided with steel well casing. A single well within the provided set of driller's logs was reported to be constructed with cement casing.

c. Well Casing Depths. Total casing depths listed on logs for which data were available ranged from 28 ft bgs to 440 ft below ground surface (bgs). Generally, casing diameters were between 5 inches and 8 inches. The single well constructed with cement was constructed with an 18-inch diameter casing. Casing depths generally appeared to be deeper in a northwest to southeast direction across the Boonville area.

d. Sanitary Seal Depths. The majority of the wells were constructed with a 20-foot deep sanitary seal. Of the private wells shown on Figure 1, seven wells had 50-foot deep sanitary seals.

e. Perforation Intervals. Most of the constructed wells were provided with long and continuous lengths of perforated casing; perforated casing was typically placed in the depth intervals from just below the depth of the sanitary seal at/nearly to the bottom of the drilled borehole. Only a few wells were provided with perforated intervals that were interspersed with sections of blank (non-perforated) casing. Hence, a majority of the DWR research wells likely have a pump-depth setting that is directly within perforated intervals of casing. This is generally not the preferable depth setting for a pump and can lead to various problems, like future sanding in wells, aeration of the water, etc.

f. "Test" Methods and Resulting Flow Rates. Where water level and pumping rate data were available from the DWR research driller's logs, the wells were "tested" by one of three methods: by airlifting water from the well for a short period of time; by bailing the groundwater from the casing for a short period of time; or by performing a pumping test with a test pump. Bailer "tests," when performed, were conducted for time periods of only 1 to 3 hrs. Airlifting "tests" were performed for periods of 2 to 4 hrs, with most of the well logs reporting "testing" periods of only 2 hours. A single pumping test was performed, but it was only in one well, and for only a period of 8 hours. The resulting flow rates from all of the reported "test data" ranged from 20 gpm to 150 gpm, with the vast majority of the logs reporting flow rates of 35 gpm or less.

   It is important to note, based on our years of experience in designing and testing water wells, that the "pumping" rates listed on drillers' logs, when no actual test was performed via pumping methods, only represent the individual driller's visual estimate of the rate of groundwater being airlifted (or bailed) from the well during relatively short-term airlifting operations (or bailer tests). As a rule of thumb, RCS geologists estimate that normal operational pumping rates for a new well equipped with a permanent pump are typically on the order of only about one-half or less than the airlifting or bailer rate reported on a driller's log.

g. Static Water Levels. Static water levels (SWLs) measured in each well prior to post-construction testing ranged in depth from 9 ft to 165 ft bgs, with a majority of the wells

**MEMORANDUM**

having SWL depths of less than 65 ft bgs at the time of “testing.” All of the 36 driller’s logs culled by BRCE listed well construction dates as being 1970 to as recent as 2014. Those wells with the deepest SWLs were outside the proposed AVCSD water service areas, i.e., generally in areas of higher elevation relative to that along the valley floor.

h. Drill Cuttings (as described by the driller). For many of the wells that lie within the “valley fill” areas of Boonville (i.e., alluvial and terrace deposits), the driller’s logs describe “brown clay” layers (mixed with interbedded sand and gravel) on top of “blue clay” layers (also mixed and interbedded with sand and gravel) through much of the total drilled depth of those boreholes. Some of boreholes drilled within the “valley fill” areas were observed to penetrate into the underlying bedrock of the Franciscan Complex. The driller’s description for these harder, bedrock materials was generally noted as “sandstone” and/or “shale”. Based on these observations, and our interpretation of the available driller’s log data, the depth to the bottom of the “valley fill” could range from 50 ft to 200 ft bgs, depending on location. Generally, those wells located along the axis of the “valley fill” area and further to the southeast appeared to encountered a thicker section of alluvium and/terrace deposits; this is particularly important because these sediments represent the principal potential water-bearing materials in the region. Further, those wells located along the margins of the valley fill areas generally encountered much thinner sections of alluvium, whereas those wells located in the hillsides to the west of the Boonville area were observed to be completely constructed within the Franciscan bedrock.

## GROUNDWATER LEVELS

To assess water levels in the Boonville area, RCS obtained SWL data in electronic format for the three MCWA nested groundwater monitoring wells (discussed herein) from the CASGEM website (www.casgem.water.ca.gov); this website is maintained by the DWR. The locations of these three nested monitoring wells, which are labeled as “AV-1”, “AV-2”, and “AV-3”, are shown on Figure 1. These nested monitoring wells were designed by others to separately monitor water levels in potentially-discrete aquifer zones perforated by each well. Water levels were available for the three monitoring wells for the period of record extending from October 2002 through March 2017. The perforation intervals for each of the three monitoring wells are:

- AV-1: 38 ft to 47 ft bgs (AV-1A) and 138 ft to 167 ft bgs (AV-1B)
- AV-2: 30 ft to 39 ft bgs (AV-2A) and 120 ft to 149 ft bgs (AV-2B)
- AV-3: 38 ft to 47 bgs (AV-3A), 125 ft to 135 ft bgs (AV-3B), and 196 ft to 225 ft bgs (AV-3C)

Figures 5A through 5C, “Water Level Hydrograph,” are hydrographs of the SWL data showing the fluctuations in water levels in each of the listed nested wells over the period of available data. These hydrographs, which show water level data for these three nested groundwater monitoring wells from October 2002 through March 2017, reveal the following:

a. Typical water levels have ranged from 1 ft in Well AV-2A (several occurrences during the monitoring period) to 47 ft in Well AV-3B (also several occurrences during the monitoring period).

b. Seasonal fluctuations have been in the range of ±2 ft in Well AV-3C to ±24 ft in Well AV-1A. Deeper water levels in these wells tend to occur between July and

**MEMORANDUM**

September of each year, whereas the shallower water levels tend to occur in between January and April of each year.

c. Water level data in these wells do not show any signs of a progressive, continuous or increasing trend in the decline of groundwater levels over time. Instead, the water level data do appear to respond seasonally with regard to rainfall (i.e., water levels are deeper in the drier summer months, and shallower in the wetter winter months). Water level trends observed in these three nested monitoring wells are generally similar to those observations made by others for water wells in the alluvial valley areas of Mendocino County. Several studies in the alluvial valleys of Mendocino County (Cardwell 1965 and Farrar 1986) have noted that overall water levels are relatively stable and that they recover rapidly to normal after periods of drought.

d. Depth to water in the alluvium and stream channel deposits (depending on the date of the measurement) was reported to vary from nearly at ground surface to 30 ft bgs, whereas in the terrace materials the water level depths varied from 10 ft to 60 ft bgs. Lenticularity of these sediments, localized pressure effects, and possible lack of hydraulic connection between permeable zones have been proposed by others to account for the lack of correlation of depth to groundwater between adjacent wells in the Anderson Valley (DPW/DWR 1956). The variation in perforated intervals in the various wells along the valley floor contribute to this explanation.

e. Groundwater flow directions generally follow the flanks of the Anderson Valley toward its axis, and thence northwesterly toward the Pacific Ocean. Thus, in the Boonville area, groundwater generally flows towards Anderson Creek and then northwest towards Philo. Groundwater in Anderson Valley reportedly occurs under both unconfined and artesian conditions. In the alluvium, it is generally unconfined conditions, but semi-confined conditions may occur in alluvium or in terrace deposits, depending on clay content and the lateral extent of the deposts (DPW/DWR 1956). In the Cache Formation, groundwater conditions may be confined to semi-confined (DPW/DWR 1956).

## PUMPING DATA

As discussed above, a majority of the 36 driller's logs culled by BRCE for this project reported that an "airlift test" was performed in those wells following construction; these types of "tests" tend to actually be the results of airlift development activities in the well by the driller immediately after installing the casing, gravel pack, and cement seal. In essence, such airlift "testing" is not designed to actually define an operational pumping rate for a new well. Such a rate can only be determined from the results of a definitive pumping test, using a test pump, following well construction.

Only a single pumping test was found to have been performed on one of those private wells. This well was located in the northern portion of the Boonville area, outside of the proposed AVCSD water service areas. Reportedly, after a pumping period of 8 hours while pumping at a rate of approximately 77 gpm, water levels had declined from a depth of 12 ft to 33 ft. The specific capacity of the well was approximately 3.6 gallons per minute per foot of water level drawdown (gpm/ft ddn). It should be noted that this well was only constructed to a depth of 42 ft and only had a 10-foot deep seal. Thus, this well was clearly extracting water from the shallow, alluvial-type deposits.

**MEMORANDUM**

As stated above, a majority of these BRCE-culled private wells were tested following their construction via airlift methods. Short-term airlifting rates were reported to have ranged between 20 and 150 gpm, with a majority of the well logs reporting rates on the order of 35 gpm or less. Based on the location of these wells, it does not appear that any specific area in and around Boonville displays higher yields than other areas. For instance, short-term yield rates of wells drilled in the northern portion of this area ranged between 30 and 80 gpm, whereas wells in the central and southern portions of the proposed service areas ranged from 20 to 65 gpm, and from 20 to 150 gpm, respectively. However, there does appear to be a greater concentration of water wells within the central and southern portions of the proposed AVCSD water service areas. This may also be due to the higher degree of commercial and/or residential development in these areas.

For those wells with driller's logs located outside the proposed AVCSD water service areas, short-term yield rates (via airlifting and/or bailing) were reported to have ranged from 20 to 77 gpm. These wells are interpreted to have been constructed within the local bedrock (i.e., Franciscan Complex rocks).

As stated above, RCS typically estimates that operational pumping for a well could be on the order of about half, or less, of the short-term airlifting rate reported on a driller's log. Therefore, based on our experience, estimated pumping rates for those wells in the research area could conceivably be in the range of 10 gpm to perhaps as high as 20 gpm or so.

## WATER QUALITY

Water quality data for several private and/or public-suplly water wells in the Boonville area were presented in the BRCE-prepared report titled, "Project Evaluation and Pre-Design Report Engineering Report for a Proposed Water System," dated June 2017; a copy of this report was provided to RCS. As discussed therein, we understand that AVCSD previously performed water quality sampling from 23 private water wells in the Boonville area in the winter of 2016. Water quality samples from those wells were analyzed for the following constituents: total coliform bacteria, E. coli bacteria, and nitrate. From those laboratory tests, the following was reported: 70% of the sampled wells (16 wells) contained E. Coli (E. Coli is not permitted in public drinking water systems); 30% (7 wells) had nitrate concentrations that were above as nitrogen the current State Water Resources Control Board (SWRCB), Division of Drinking Water (DDDW) Primary Maximum Contaminant Level (MCL) of 10 milligrams per liter (mg/L); and 61% (14 wells) had nitrate (as N) concentrations greater than 8 mg/L.

There are currently four public water supply systems in the Boonville area: Meadow Estates Mutual Water Company (Meadow Estates MWC); Anderson Valley High School, Anderson Valley Elementary; and Anderson Valley Brewing Company. Figure 6, "Wells with Water Quality Data," shows the general location for each of these public-supply water systems and those wells within the water system. Water quality data for water wells in these public water supply systems are available to the public from the SWRCB DDW water quality database. This database is available through the SWRCB Electronic Data Transfer (EDT) website (http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.shtml). Note that there are no water quality data available for the Anderson Valley Brewing Company, because this is a relatively new public water system. Generally, of those constituents analyzed and reported on the DDW database for each public-supply water well owned by the 3 other publich systems, concentrations of those constituents analyzed were reported to be below their

**MEMORANDUM**

respective DDW Primary and/or Secondary MCLs. However, concentrations of a few analytes in certain wells were reported to exceed their respective MCLs. A summary of those detected elevated analytes in each public supply water system is as follows:

<u>Meadow Estate MWC</u>

- The Meadow Estate MWC has 4 active water wells in its public water supply system. These wells are generally located in the central portion of Boonville, as shown on Figure 6.
- Elevated concentrations of aluminum (Al) ranging from 1,400 micrograms per liter (µg/L) to 1,700 µg/L were reported in samples collected from Meadow Estates MWC Well Nos. 3 and 5 in 2013 and 2016, respectively.
- Elevated concentrations of iron (Fe) ranging from 520 micrograms per liter (µg/L) to 39,000 µg/L were reported in various samples collected in Meadow Estates MWC Well Nos. 2, 3, 4, and 5 between 2004 and 2016.
- Elevated concentrations of manganese (Mn) were reported in Meadow Estates MWC Well Nos. 2, 3, 4, and 5, ranging from 68 µg/L to 420 µg/L, between 2001 and 2016.
- Of those samples with elevated concentration of the analytes discussed above, turbidity was also reported to be elevated at values ranging from 16 nephelometric turbidity units (NTUs) to 540 NTUs.

<u>Anderson Valley High School</u>

- Anderson Valley High School appears to have as many as 6 water wells in its public supply water system, as reported in the DDW database. Anderson Valley High School is generally located in the southern portion of Boonville, and is in the proposed AVCSD water services area.
- Elevated concentrations of aluminum (1,100 µg/L), iron (600 to 1,300 µg/L), manganese (55 to 110 µg/L), and turbidity (5.3 to 39 NTUs) were reported in two of the water wells from samples collected in 2009 from the school wells. Note once again that turbidity values were generally high.

In our experience, laboratory test results for groundwater samples having high turbidity values often display anomalously high concentrations of Al, Fe, Mn, and other inorganic chemicals, like arsenic. Hence, the presence of elevated turbidity in the groundwater samples tested by the laboratory can explain some of the high concentrations reported for those constituents for the water systems discussed above.

<u>Anderson Valley Elementary School</u>

- The Anderson Valley Elementary School is located in the northern portion of Boonville and within the proposed AVCSD water service area. Per the DDW water quality database, there appears to be only one active well for this water supply system.
- Elevated concentrations of iron (440 µg/L), manganese (550 µg/L), and possibly 1,2,3-TCP were reported in onsite Well No. 2 for samples collected between 2000 and 2005.

**MEMORANDUM**

From our review of the laboratory data from the DDW water quality database for these public supply water wells, it appeared that several turbid samples were collected from these wells. Again, when such turbid groundwater is tested for inorganic chemicals (trace or heavy metals), "false positives" for metals like Al, Fe and Mn can be reported by the laboratory, as mentioned above. Hence, at least some of the elevated detections in these public supply wells might be attributed to such "false positives."

BRCE staff also collected water quality samples between May and June 2017 from 5 private wells on properties that were reviewed as part of the DWR well research work discussed above; the locations of these five private wells are shown on Figure 6. Those water quality samples were analyzed for the following constituents: arsenic (As); iron (Fe); manganese (Mn); nitrate as N; and nitrite as N. Table 1, "Summary of Water Quality Data for Private Wells," summarizes the results of this water quality sampling performed by BRCE. Data presented on Table 1 reveal the following with regard to those analyzed constituents.

- Nitrite as nitrogen, arsenic, and iron were not detected in each of those 5 private wells.
- Nitrate was detected at concentrations ranging from 1.6 mg/L to 5.2 mg/L; nitrate detections occurred in those wells located in the central and southern portions of Boonville.
- Manganese was detected at concentrations of 180 µg/L and 230 µg/L in two wells located in the northern and central portions of Boonville.

More complete groundwater quality data were publicly available for the three MCWA nested wells discussed above. This water quality data was available in electronic format on DWR's water data library website (http://www.water.ca.gov/waterdatalibrary/), but only from a single sampling event which took place on May 5, 2010. Table 2, "Summary of Available Water Quality Data for MCWA Nested Monitoring Wells," summarizes the results of available water quality data for these three MCWA nested groundwater monitoring wells. These more complete water quality data from these nested monitoring wells reveal the following:

- The groundwater tends to have a calcium- to sodium-bicarbonate water character.
- Total dissolved solids (TDS) concentrations for the three wells ranged between 189 mg/L and 622 mg/L. The TDS concentrations of 345 mg/L and 622 mg/L in Wells AV-3A (perforated at 38 to 47 ft bgs), and AV-3B (perforated at 125 to 135 ft bgs), respectively, are excessive when compared to the other samples collected in the nested monitoring wells.
- Total hardness (TH) concentrations ranged from 61 to 167 mg/L. TH appears to decrease in the deeper perforated wells.
- The groundwater tends to have low to very low concentrations of sulfate and magnesium.
- Boron (B), with a California Notification Level (NL) of 1000 µg/L, was reported at concentrations in the three nested monitoring wells as follows: not detected (ND) and 100 µg/L in AV-1A and AV-1B, respectively; 200 µg/L and 300 µg/L in AV-2A and AV-2B, respectively; and from 100 µg/L in AV-3C to 4,700 µg/L in AV-3B. Boron was reported to exceed its NL only in Wells AV-3A and AV-3B.

**MEMORANDUM**

- Nitrate (as $NO_3$), with a Primary MCL of 45 mg/L in dringking water was encountered as follows: ND or below the Primary MCL of 45 mg/L in each of the three nested monitoring wells. Nitrate was only detected in AV-1A (perforations from 37 ft to 48 ft bgs) at a concentration of 8.6 mg/L, and in AV-3C (perforations from 196 ft to 225 ft bgs) at a concentration of 0.4 mg/L.
- Arsenic (As), with a Primary MCL of 10 µg/L, had reported concentrations as follows: from ND in AV-1A and 1 µg/L in AV-1B; 2 µg/L (in AV-2A) and 7 µg/L (in AV-2B); and from 5 µg/L (in AV-3A and AV-3C) to 6 µg/L (in AV-3B). These reported As concentrations are all below the Primary MCL of 10 µg/L. As could be increased in the deeper perforated wells.
- Iron (Fe), with a Secondary MCL of 300 µg/L, had reported concentrations as follows: ND in AV-1A and AV-1B, respectively; 6 µg/L to 41 µg/L in AV-2A and AV-2B, respectively; and from 6 µg/L in AV-3C to 868 µg/L in AV-3A. The Fe values in Well AV-3A was the only reported concentration of Fe that exceeded the Secondary MCL of 300 µg/L for this constituent.
- Manganese (Mn), with a Secondary MCL of 50 µg/L, had reported concentrations during the single sampling event as follows: ND in AV-1A and AV-1B, respectively; 14 µg/L and 119 µg/L in AV-2A and AV-2B, respectively; and from 88 µg/L in AV-3B to 565 µg/L in AV-3A. Thus, Mn concentrations exceeded the Secondary MCL of 50 µg/L for this constituent in Wells AV-2B, AV-3A, AV-3B, and AV-3C.

From our review of the laboratory data for these three nested MCWA monitoring wells, it is possible that some of the elevated concentrations of aluminum, boron, iron, and manganese are the result of turbidity in the water samples. From information provided on the DWR website, these samples were collected via the use of a HydraSleeve (this method collects an in-situ grab sample of the groundwater inside the casing). HydraSleeves are designed to sample ambient groundwater. Based on the data provided on the DWR website, it appears these monitoring wells were not pumped or purged prior to sampling; thus it is highly likely that turbid groundwater samples were collected (unfortunately, turbidity measurements were not provided in the laboratory test data). In wells that have not been pumped for long periods of time, as is possible with these monitoring wells prior to the sampling event, biofouling of the well casing can occur. This biofouling can also lead to formation of iron and manganese in the groundwater stored inside the well casing, which could also lead to “false positives”. Hence, at least some of the excessive Al, B, Fe, and Mn detections observed in AV-2B, AV-3A, AV-3B, and AV-3C wells might be attributed to such “false positives.”

## POTENTIALLY CONTAMINATING ACTIVITIES

A preliminary inventory of past and current potentially contaminating activities (PCAs) was compiled using readily available data for the area. Our preliminary assessment was performed using: the SWRCB GeoTracker website’s (https://geotracker.waterboards.ca.gov/) compilation of leaking underground storage tank (LUST) cleanup sites; and the Department of Toxic Substances Control (DTSC) EnviroStor website (https://www.envirostor.dtsc.ca.gov/public/), which shows cleanup sites, land disposal sites, waste permit sites, permitted underground storage tank (UST) sites, the locations of groundwater monitoring wells, and sites where evaluations and soils/groundwater cleanups are being conducted by others.

**MEMORANDUM**

Figure 7, “Map of GeoTracker Sites,” illustrates the locations of the reported PCAs within the Boonville area and its environs. Also shown on Figure 7 are the boundaries for the AVCSD water service areas. Figure 7 shows that there are 13 PCAs in the Boonville area. Of these sites, 10 are listed LUST sites (shown as solid and semi-filled red squares on Figure 7); one is a “cleanup site” (shown as a solid green square); one is a landfill site (shown as a solid orange square); and one is a permitted UST site (shown as a solid dark brown square). These PCAs are generally located near Highway 128, where a majority of the commercial development is located in the Boonville area. For seven of the 10 LUST sites, the website(s) stated that site investigations were to be “completed” and/or “closed” (shown as semi-filled red squares). Generally, these closed LUST sites were reported to be an area where gasoline leaked only into the subsurface soil beneath the respective PCA. In some instances, the “potential media of concern” was reported to be the “aquifer used for drinking water supply.” In those instances where groundwater quality data were available, it appeared that some type of remediation and groundwater monitoring had been performed prior to final approval and/or closure of the LUST site by the SWRCB.

At the time of our review, there were reportedly still three open LUST sites and one open cleanup site in the Boonville area, as shown on Figure 7. Below is a summary of the information and data available for these “active” PCA sites, moving from northwest to southeast in the Boonville area:

1. The LUST site listed as “Anderson Valley US Bus Barn” is located at the address of 12300 Anderson Valley Way, in the northwest portion of Boonville, as shown on Figure 7. The GeoTracker website lists diesel and gasoline as the potential contaminants of concern and these contaminants may have impacted the local groundwater. Per historical reports on the GeoTracker website, two USTs were removed from this school property in 1990 and 1993. Both of these USTs were reported to have leaked and impacted the soil and groundwater at the site. After the impacted soils were excavated from the site in 1995, new groundwater monitoring wells were installed at the site. Results of initial water quality sampling revealed that concentrations of petroleum hydrocarbons were detected in samples collected from the onsite monitoring wells and domestic wells at the school, as well as in nearby private domestic wells that were also sampled. More recent results of groundwater sampling from the monitoring wells in December 2016 revealed that diesel range organics (DRO) were detected in two monitoring wells at concentrations of 68 µg/L and 576 µg/L. Continued characterization and remediation of the potential petroleum hydrocarbons that have impacted the site and nearby wells was recommended by others. Groundwater flow direction was reported to be to the southwest towards Anderson Creek, with a hydraulic gradient ranging from 0.05 to 0.08 feet/foot (ft/ft).

2. An open cleanup site listed as “CDOT Boonville Maintenance Station” was reported to be located at 13550 Anderson Valley Way, which is generally located in the central portion of Boonville. This site was previously used for washing vehicles owned by the California Department of Transportation (CDOT). The status of this cleanup site was noted as “Open – eligible for closure as of 6/22/2017”. Per the GeoTracker website, the potential contaminants of concern are listed as diesel, gasoline, and lead; and these contaminants may have impacted the subsurface soil and local groundwater. This site was also formerly a “closed” LUST site as of 1996. Groundwater flow direction was reported to be west and/or northwest towards

**MEMORANDUM**

Anderson Creek. A "No Further Action" request to the SWRCB was made by others in 2011. Reportedly, this site will most likely be considered "closed" as a contaminated site.

3. The LUST site listed as "Chevron #9-6221" is reported to exist at the address of 14125 Highway 128. This site is located in the southeastern portion of Boonville. This site lists its cleanup status as "open – site assessment as of 6/22/17". Per the GeoTracker website, benzene, diesel, and gasoline are listed as the potential contaminants of concern, and these contaminants may have impacted the subsurface soil and local groundwater. Based on reports available on the GeoTracker website, the site was used as a Chevron service station up until 1942. All structures onsite were demolished by 1955. A new Chevron service station was then constructed onsite (date unknown), and it too was subsequently demolished (in 1981). Three onsite USTs were reported to have been leaking and were subsequently removed in 1978 and replaced with new tanks. The new tanks were then removed when the gas station was demolished. There is no information on water quality, groundwater flow direction, or groundwater gradient for this this site. Reportedly, the site will undergo a site assessment in 2017 to determine what type of remediation should be implemented. The site is reportedly occupied at this time by Philo Ridge Winery Tasting Room.

4. The LUST site listed "Chevron, Jeff" is reported to exist at the address of 14289 Highway 128, in the southeast portion of Boonville. Per the GeoTracker website, diesel, gasoline, methyl tert-butyl ether (MTBE), tert-butyl alcohol (TBA), and other fuel oxygenate are listed as the potential contaminants of concern. The current cleanup status is listed as "open – assessment and interim remedial action as of 6/22/17." Historically, the site was used as an automotive service station between from 1955 to 1981, and then as a Chevron service station from 1984 to 1998. Reportedly, diesel was detected in several wells in the vicinity of the site in 1988. Thus, a Cleanup and Abatement Order was issued by the SWRCB for this site in 1989. Groundwater monitoring and sampling of onsite and offsite monitoring wells have been conducted by others sporadically since 1992. In a 2015 study performed by other for this site, it was reported that contamination of the soil and groundwater generally occurred. As of December 2015, the site was reportedly occupied by a grocery store and former auto shop.

   Based on the available data on the GeoTracker website, the most recent groundwater sampling event occurred in March 2017. Results of this sampling revealed the following: gasoline range organics (GRO) were detected in one well at a concentration of 88 µg/L; diesel range organics (DRO) ranged from 133 µg/L to 654 µg/L in two separate wells; and MTBE and TBA were detected in one well at concentrations of 17.6 µg/L and 12.1 µg/L, respectively. No other analyzed constituents were detected at or above their laboratory reporting limits in those groundwater samples collected. Based on our review of the isoconcentration maps provided on the GeoTracker website, it appeared that any groundwater contamination was generally localized to the site. Recommendations were made by others to continue groundwater monitoring and sampling for petroleum hydrocarbons at this site. Groundwater flow direction was reported to be to the northwest and at gradients ranging from 0.01 to 0.1 ft/ft.

**MEMORANDUM**

## Key Conclusions and Recommendations

- In our opinion, it is considered to be hydrogeologically feasible to develop groundwater supplies for community purposes by AVCSD within the proposed AVCSD water service areas at/near Boonville.
- Groundwater yields to wells constructed within the alluvium and terrace deposits are reported to range from 5 to 300 gpm, but average about 10 to 50 gpm, whereas water level drawdown amounts at these rates were on the order of 70 ft or greater. Calculated specific capacities average between 0.1 gallons per minute per foot of water level drawdown (gpm/ft ddn) and 5 gpm/ft ddn. The greater thickness of terrace deposits usually results in higher yields, but specific capacity is greater in the more permeable alluvial and stream channel deposits (DPW/DWR 1956). Virtually each of the proposed AVCSD water service areas are underlain by alluvium (map symbol Qal on Figure 3) and/or non-marine terrace deposits (map symbol Qt).
- Local groundwater resources may be developed via the use of existing, privately-owned water wells and/or via the drilling, construction and testing of new wells. Based on the total combined desired groundwater supply of 90 to 120 gpm, and depending on the selected proposed water service area, as many as 4 or 6 new water-supply wells could be needed to meet those instantaneous flow demands.
- The primary source of groundwater for new wells in the area appear to be from the alluvial-type deposits found along Anderson Creek and terrace deposits found along the margins of the Anderson Valley. Based on our review of the published geologic maps, and the geologic logs of nested monitoring wells, and our interpretation of the driller's descriptions of the earth materials encountered during drilling for water wells in the area, the thickest sections of alluvium and terrace deposits appear to be along the axis of the Anderson Creek, which traverses in a northwest direction across Anderson Valley, and in the central portion of the Anderson Valley.
- The anticipated general water quality of the groundwater in the alluvial- and terrace-type deposits is: low total dissolved solids; moderate total hardness; a calcium to sodium bicarbonate water character; and low to very low concentrations of sulfate and magnesium. Elevated concentrations of iron and/or manganese may occur in any well within the Boonville area. Hence, treatment for these constituents may be required in any existing and/or new well used by the AVCSD for public-supply.
- Water quality data from the three MWCA nested groundwater monitoring wells from samples collected in 2010 revealed that elevated concentrations of aluminum, boron, iron, and manganese reportedly occurred in all 3 depth zones screened in Well AV-3 (located in the northern portion of the proposed water service areas). These constituent were not detected or were detected at concentrations below their respective DDW Primary and/or Secondary MCLs in Well AV-1 (located in southern portion of proposed water service areas) and Well AV-2 (located in the central portion of the proposed water service areas), with the exception of manganese, which was reported to be above its Secondary MCL of 50 µg/L in the deepest screened zone in AV-2 (zone AV-2B, with perforations from 120 ft to 149 ft).
- There were four open cleanup and/or LUST sites reported to be within the proposed AVCSD water service areas. Generally, each of the four sites listed diesel, gasoline,

**MEMORANDUM**

and/or other petroleum hydrocarbons as the primary contaminants. For a some of these cleanup sites, contamination of groundwater had impacted onsite monitoring wells and proximal, but offsite, privately-owned water wells near those PCAs. The open LUST site listed as "Anderson Valley US Bus Barn," which is located in the northern portion of the proposed water service areas, appears to have impacted both onsite and nearby offsite wells used for domestic-supply with petroleum hydrocarbons. This site may still be under continued characterization and remediation. The cleanup site listed as "CDOT Boonville Maintenance Station," and located in the central portion of the proposed water service areas, is likely to be closed as a contamination site. The remaining two open LUST sites are located in the southern portion of the proposed water service areas. Based on the information available, groundwater contamination at these two sites is likely to be localized. In addition, groundwater flow at these sites appears to be toward the northwest, and away from possible groundwater development areas for AVCSD.

- Based on the information presented herein, we would recommend that AVCSD try to develop groundwater resources in the central and southern portions of proposed water service areas.

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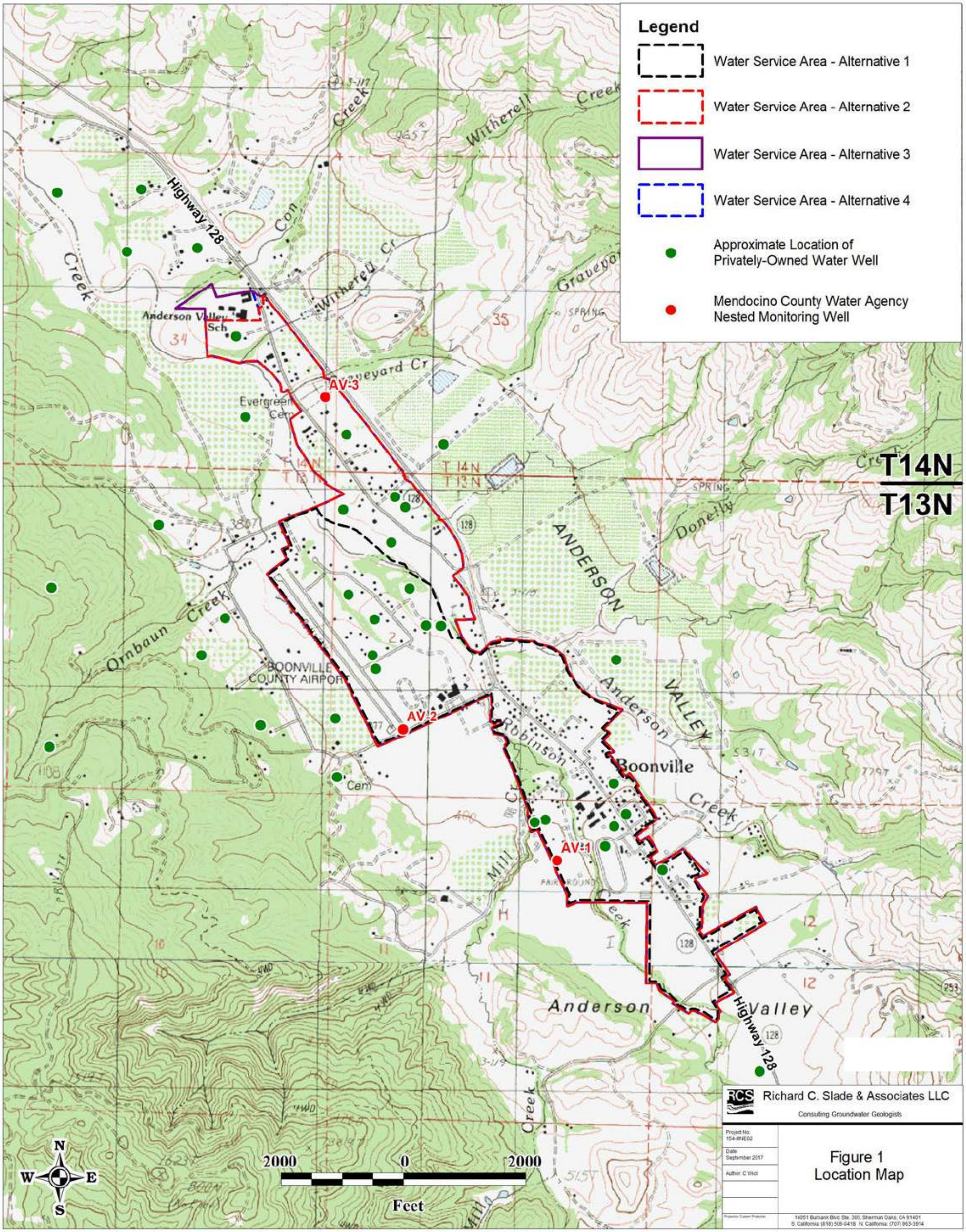



Figure 1
Location Map

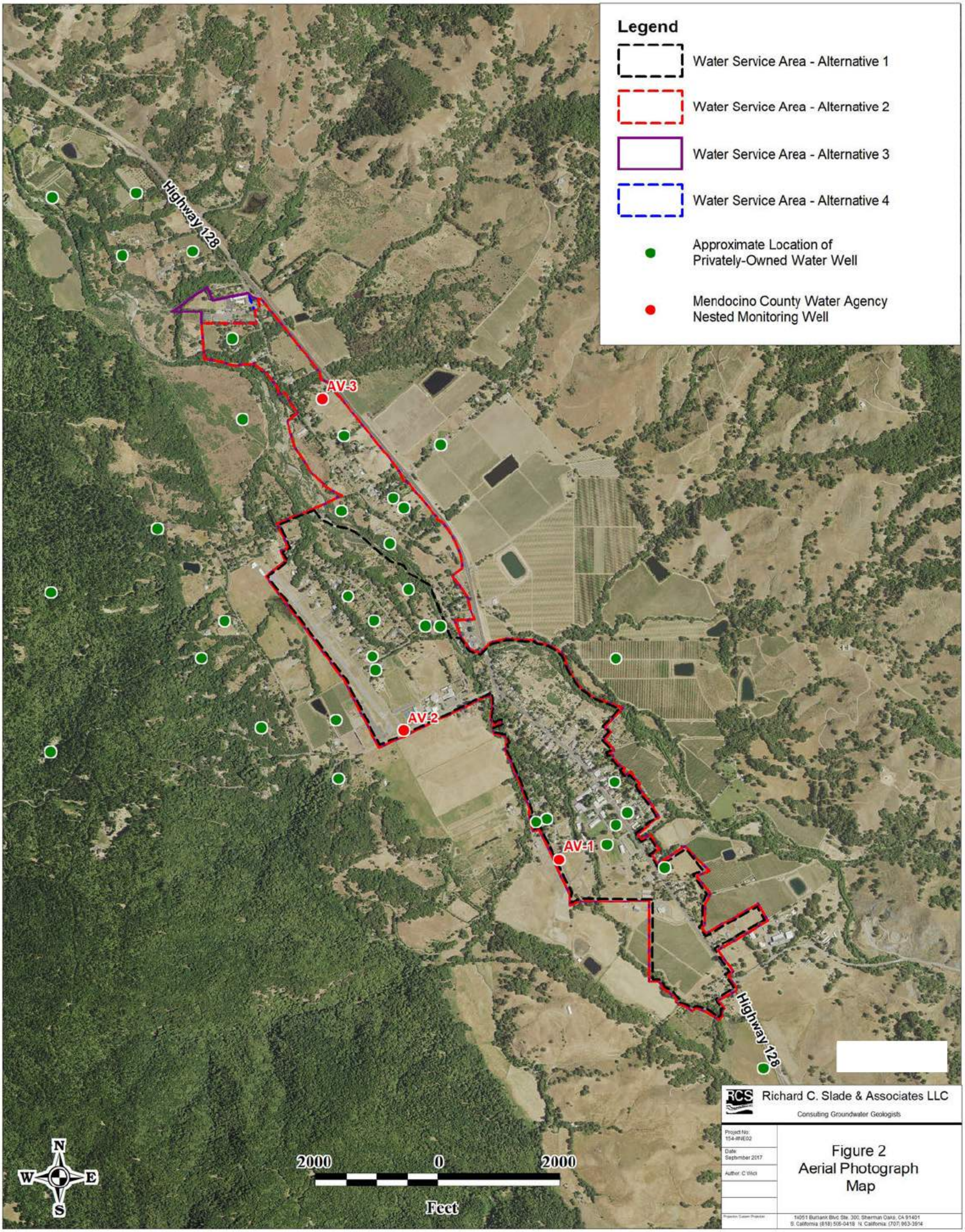
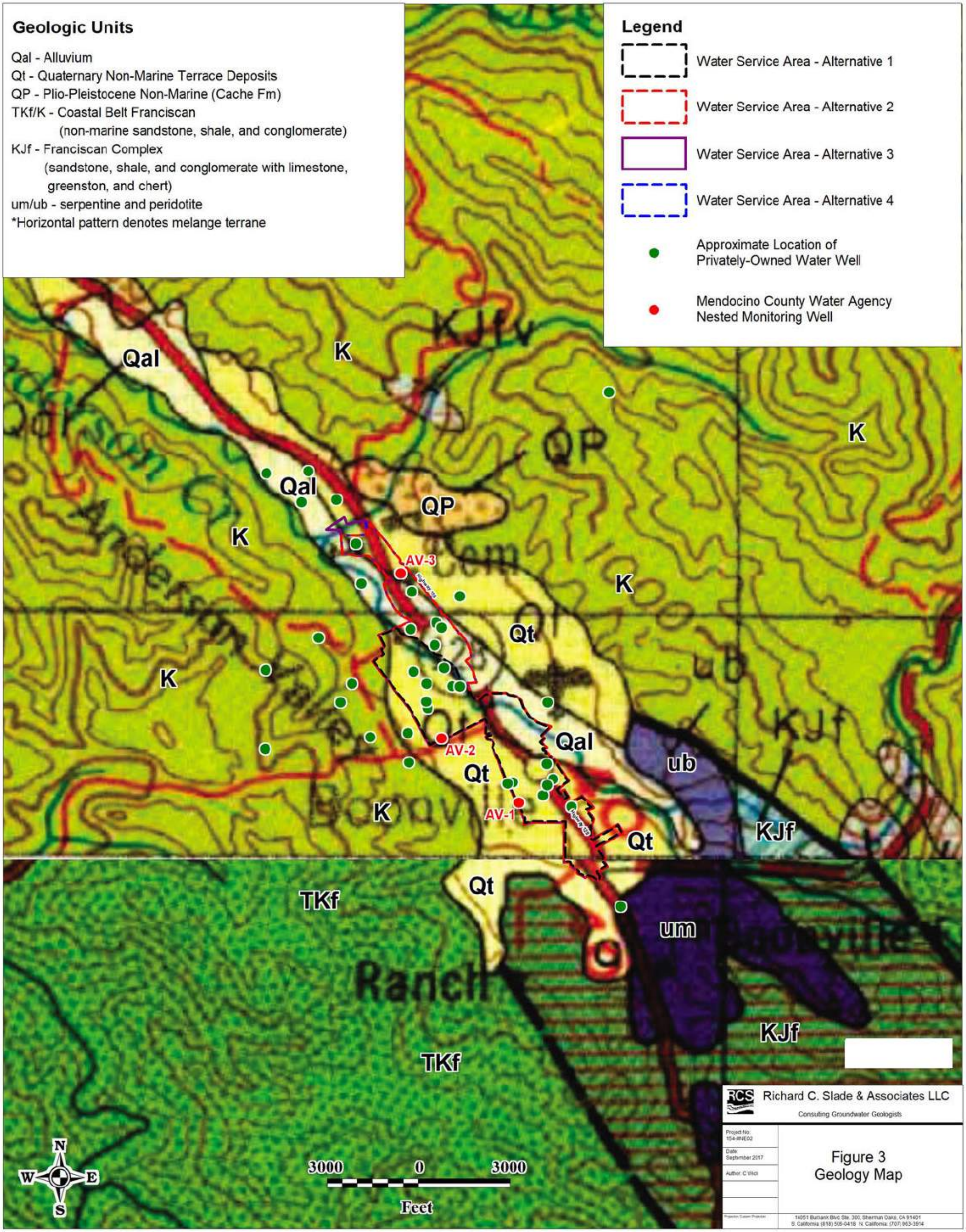



Figure 2
Aerial Photograph Map


Geologic Units
Qal - Alluvium
Qt - Quaternary Non-Marine Terrace Deposits
QP - Plio-Pleistocene Non-Marine (Cache Fm)
TKf/K - Coastal Belt Franciscan
(non-marine sandstone, shale, and conglomerate)
KJf - Franciscan Complex
(sandstone, shale, and conglomerate with limestone, greenston, and chert)
um/ub - serpentine and peridotite
*Horizontal pattern denotes melange terrane
Legend
Water Service Area - Alternative 1
Water Service Area - Alternative 2
Water Service Area - Alternative 3
Water Service Area - Alternative 4
Approximate Location of Privately-Owned Water Well
Mendocino County Water Agency Nested Monitoring Well
Qal
K
KJfv
QP
QP
K
K
Qt
K
ub
KJf
Qal
ub
Qt
K
KJf
Qt
AV-3
AV-2
AV-1
Qt
TKf
um
Ranch
KJf
TKf
N
W
E
S
3000
0
3000
Feet
Richard C. Slade & Associates LLC
Consulting Groundwater Geologists
Project No: 154-INE02
Date September 2017
Author: C Wick
Figure 3
Geology Map
14051 Burbank Blvd Ste. 300, Sherman Oaks, CA 91401
S. California (818) 506-0418 N. California: (707) 963-3914

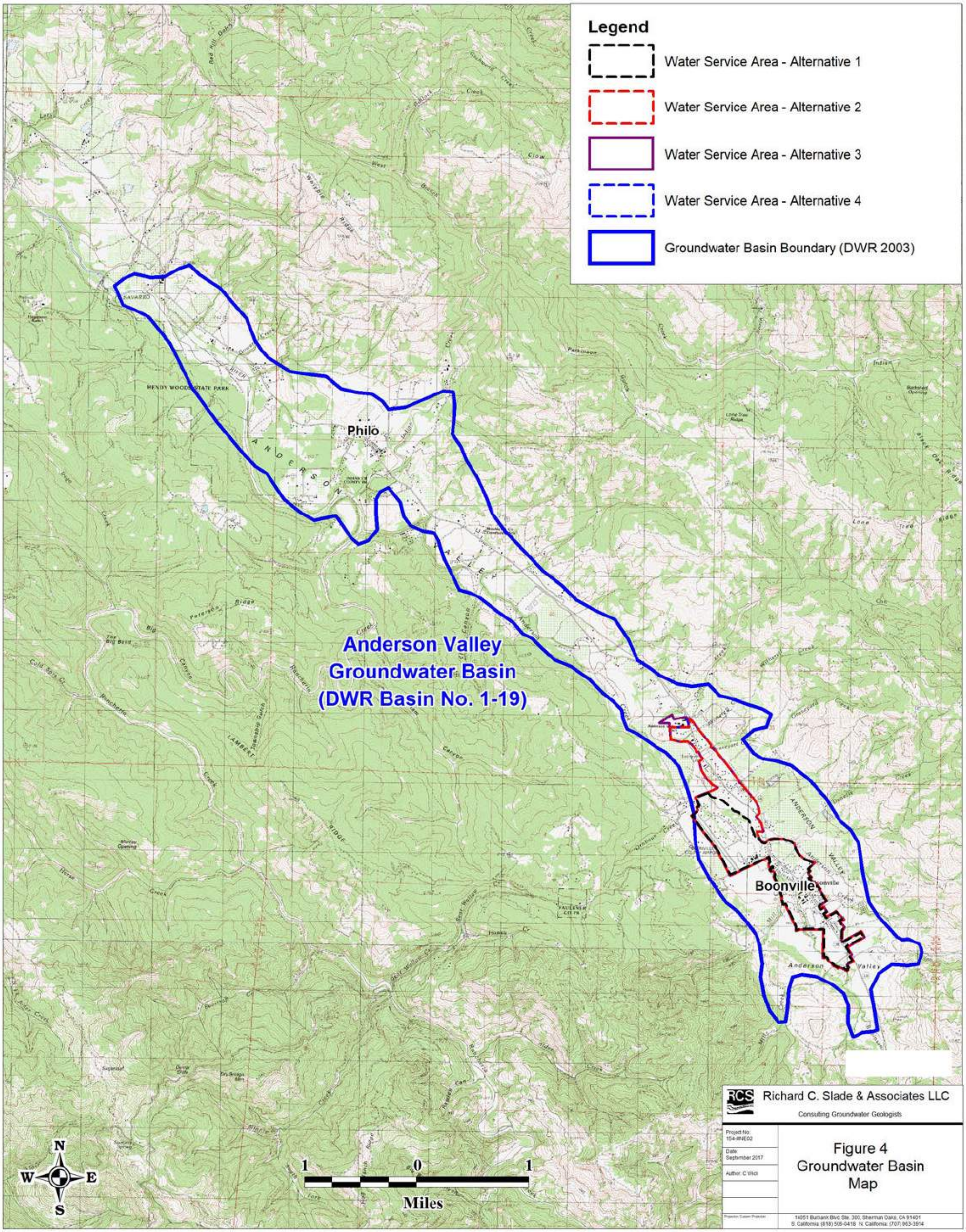


Figure 4
Groundwater Basin Map

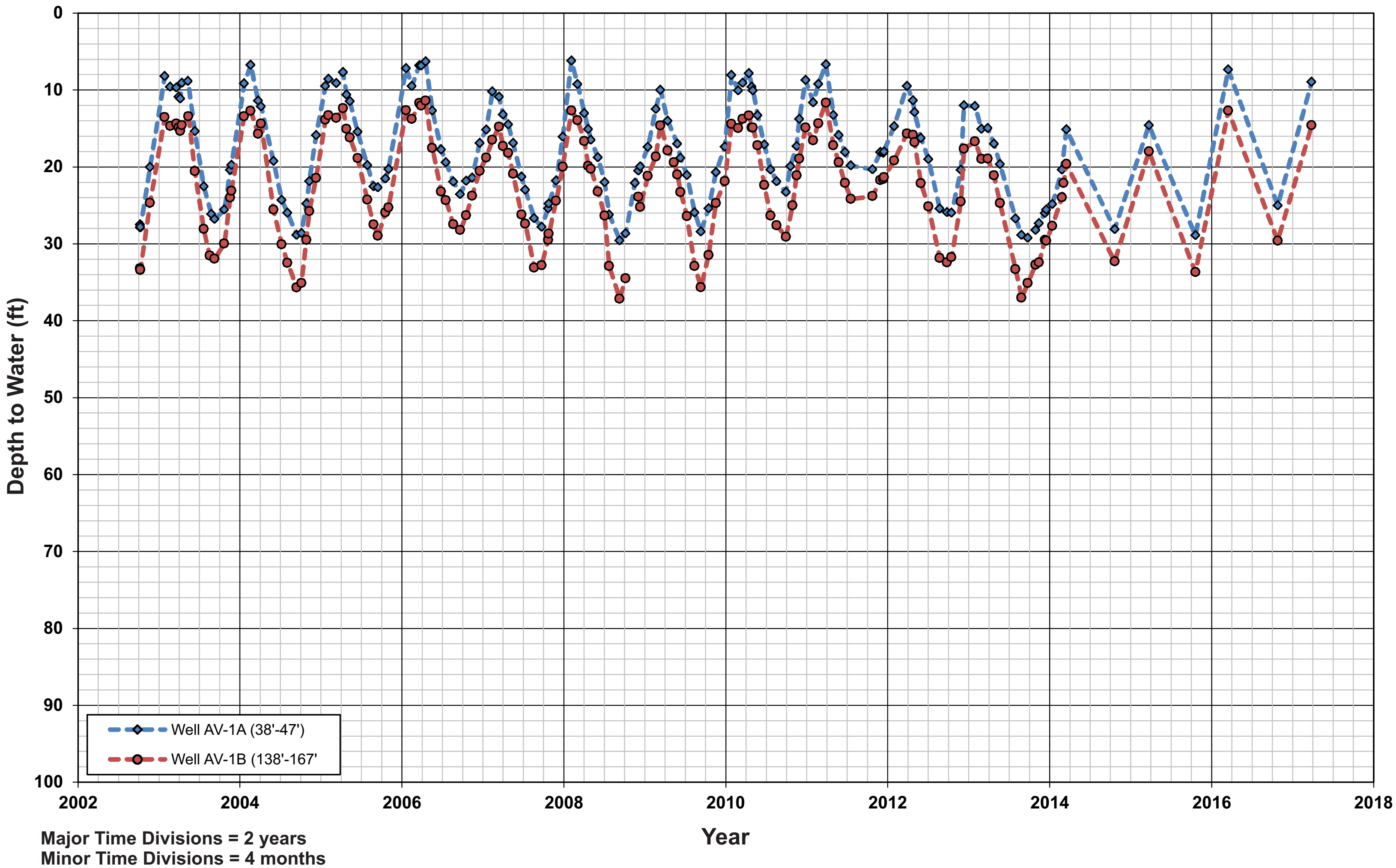



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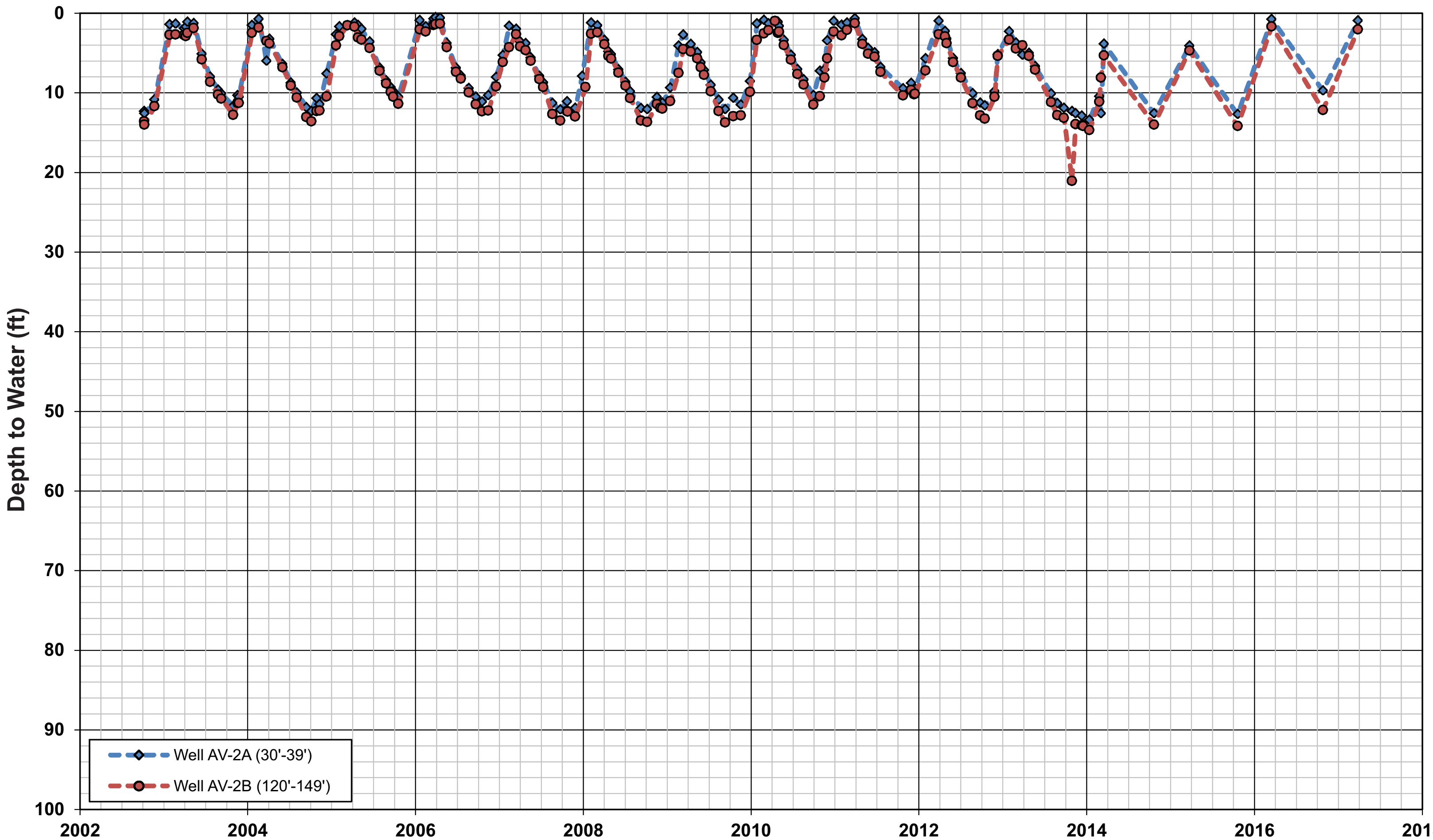
**FIGURE 5A**
**WATER LEVEL HYDROGRAPH FOR**
**MCWA AV-1 GROUNDWATER MONITORING WELL**

**Job No. 154-MNE02** **September 2017**




**Major Time Divisions = 2 years**
**Minor Time Divisions = 4 months**


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**FIGURE 5B**
**WATER LEVEL HYDROGRAPH FOR**
**MCWA AV-1 GROUNDWATER MONITORING WELL**

**Job No. 154-MNE02** **September 2017**

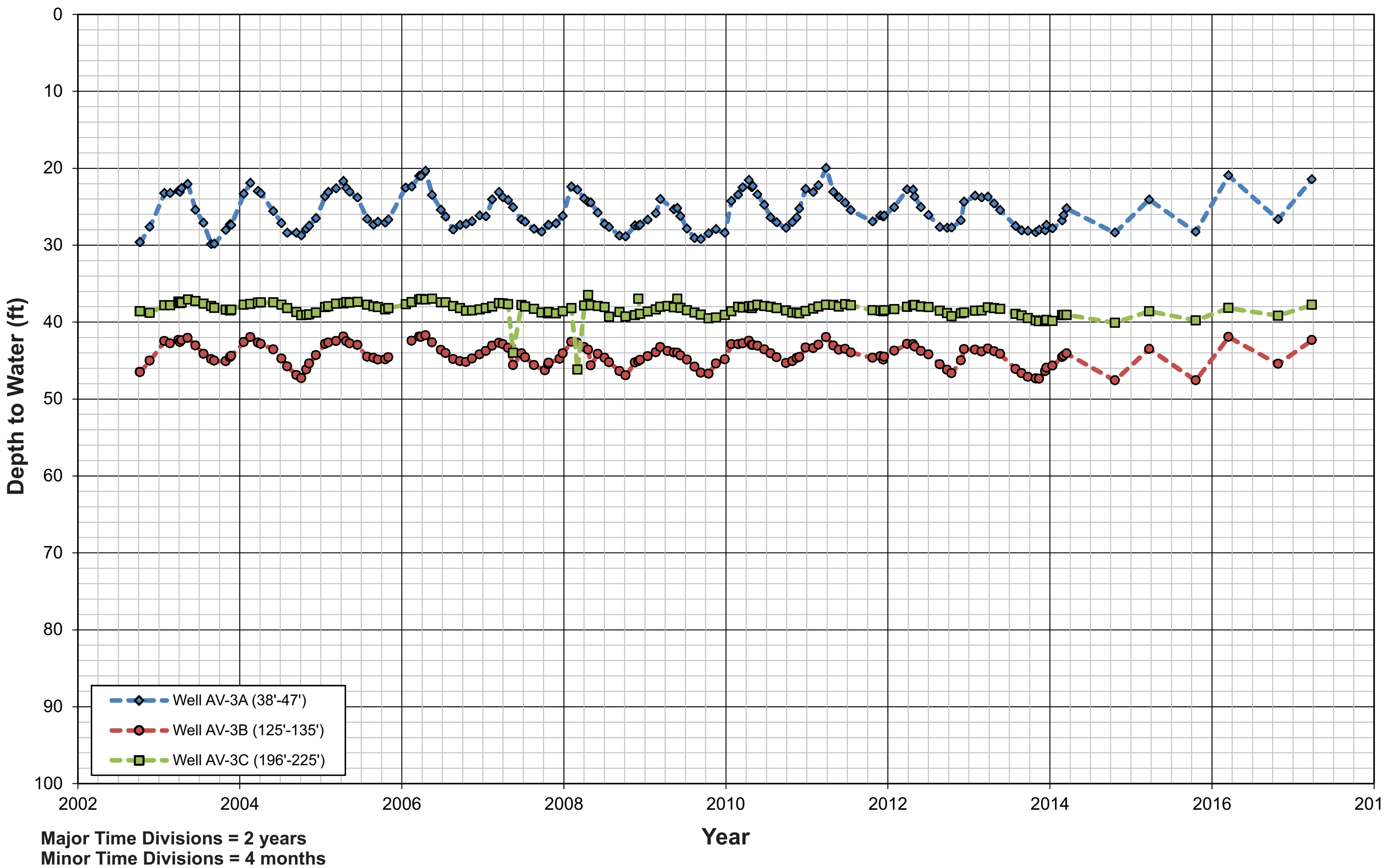



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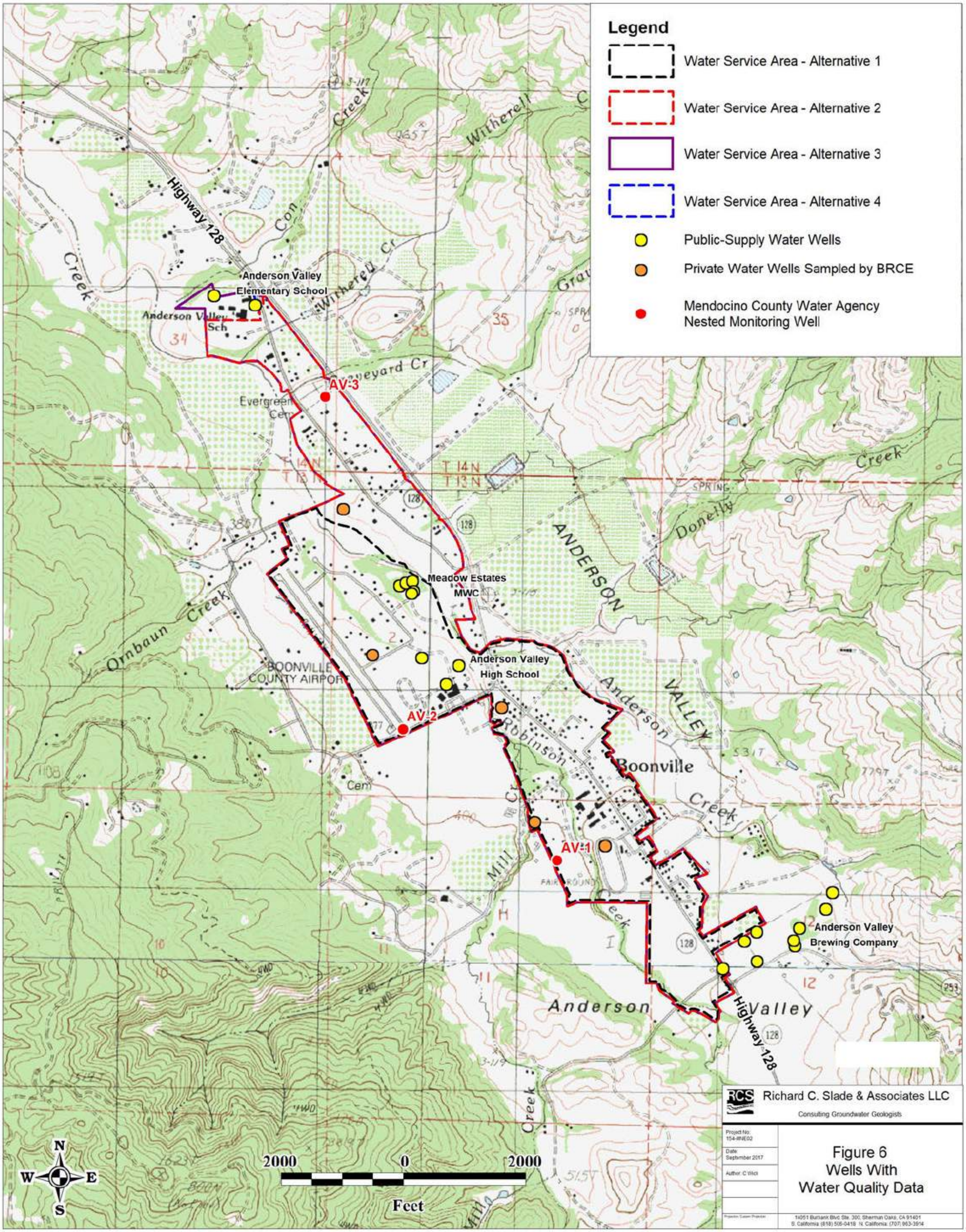
**FIGURE 5C**
**WATER LEVEL HYDROGRAPH FOR**
**MCWA AV-1 GROUNDWATER MONITORING WELL**

**Job No. 154-MNE02** **September 2017**



Legend
Water Service Area - Alternative 1
Water Service Area - Alternative 2
Water Service Area - Alternative 3
Water Service Area - Alternative 4
Public-Supply Water Wells
Private Water Wells Sampled by BRCE
Mendocino County Water Agency
Nested Monitoring Well
Highway 128
Anderson Valley
Elementary School
Meadow Estates
MWC
Anderson Valley
High School
AV-1
AV-2
AV-3
Anderson Valley
Brewing Company
Boonville
BOONVILLE
COUNTY AIRPORT
Evergreen
Cem
ANDERSON
VALLEY
Anderson
Valley
Robinson
Creek
Mill
Ornbaun
Witherell
Donelly
2000
0
2000
Feet
N
S
E
W
Richard C. Slade & Associates LLC
Consulting Groundwater Geologists
Project No:
154-INE02
Date:
September 2017
Author: C Wick
Figure 6
Wells With
Water Quality Data

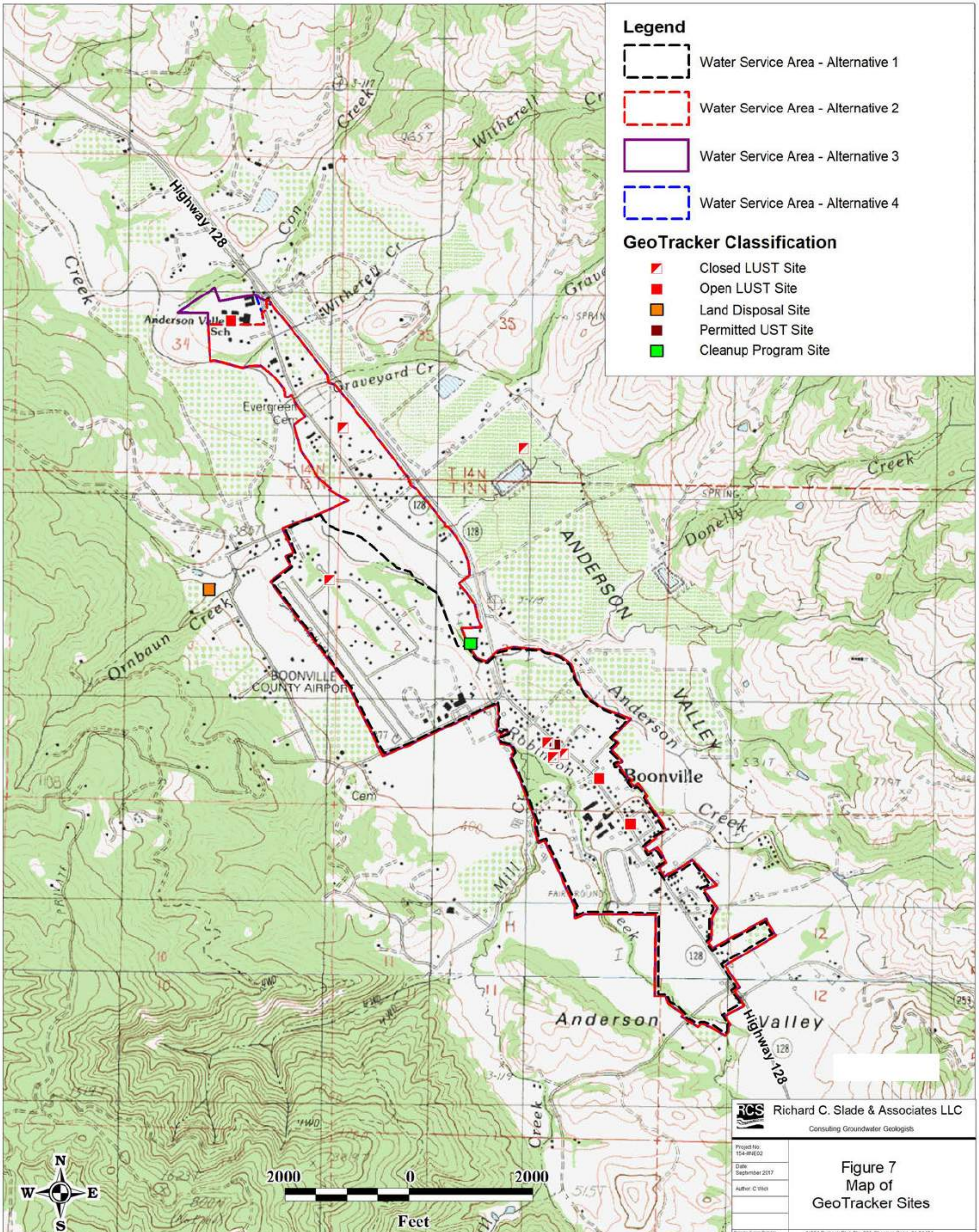



Figure 7
Map of
GeoTracker Sites

# TABLE 1
## SUMMARY OF WATER QUALITY DATA FOR PRIVATE WELLS
## VICINITY BOONVILLE, MENDOCINO COUNTY, CALIFORNIA

| Location (Address) of Private Well | | | 12940 Anderson Valley Way | 13461 Airport Road | 13750 Highway 128 | 18251 Lambert Lane | 14400 Highway 128 (Mendocino County Fairgrounds) |
|---|---|---|---|---|---|---|---|
| Assessors Parcel Number (APN): | | | 029-430-04 | 029-480-51 | 029-110-01 | 029-150-28 | 029-150-06 |
| General Perforation Interval (ft): | | | 36-56 | 30-120 | No Data | 40-120 | 20-440 |
| Sample Date: | | | 5/15/2017 | 6/28/2017 | 6/28/2017 | 6/28/2017 | 6/6/2017 |
| General Well Location Within Proposed AVCSD Water Service Areas: | | | Northern | Central | Central | Southern | Southern |
| **Constituent Analyzed** | **Units** | **Maximum Contaminant Level** | | | | | |
| **Analyzed General Mineral Constituents** | | | | | | | |
| **Nitrate as N** | mg/L | 10 (P) | <0.40 | <0.40 | 2.2 | 1.6 | 5.2 |
| **Nitrite as N** | | 1 (P) | <0.40 | <0.40 | <0.40 | <0.40 | <0.40 |
| **Analyzed Inorganic Constituents (Trace Elements)[(2)]** | | | | | | | |
| **Arsenic** | µg/L | 10 (P) | <2 | <2 | <2 | <2 | <2 |
| **Iron** | | 300 (S) | <100 | <100 | <100 | <100 | <100 |
| **Manganese** | | 50 (S) | 230 | 180 | <20 | <20 | <20 |

**NOTES:** Water quality data source: Laboratory reports from Brelje and Race Laboratories, Inc.
(1) The three listed numbers represent the recommended, upper and short-term Secondary Maximum Contaminant Levels for the constituent.
mg/L = milligrams per liter
µg/L = micrograms per liter
<0.40 = not detected and/or detecting below laboratory reporting limits
(P) = Primary; (S) = Secondary

# TABLE 2
# SUMMARY OF AVAILABLE WATER QUALITY DATA
# MENDOCINO COUNTY WATER AGENCY NESTED MONITORING WELLS
# VICINITY BOONVILLE, MENDOCINO COUNTY, CALIFORNIA

| Constituent Analyzed | Units | Maximum Contaminant Level | WELL AV-1 | | WELL AV-2 | | WELL AV-3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | AV-1A | AV-1B | AV-2A | AV-2B | AV-3A | AV-3B | AV-3C |
| General Perforation Interval (ft): | | | 38-47 | 138-167 | 30-39 | 120-149 | 38-47 | 125-135 | 196-225 |
| Sample Date: | | | 5/5/2010 | | 5/5/2010 | | 5/5/2010 | | |
| General Well Location Within Proposed AVCSD Water Service Areas: | | | Southern | | Central | | Northern | | |
| **General Physical Constituents[1]** | | | | | | | | | |
| Specific Conductance | umhos/cm | 900; 1,600; 2,200[2] | 350 | 317 | 433 | 427 | 575 | 876 | 373 |
| pH | units | None | 7.7 | 7.8 | 7.6 | 7.9 | 8.1 | 8.1 | 7.3 |
| **General Mineral Constituents** | | | | | | | | | |
| Total Dissolved Solids | mg/L | 500; 1,000; 1,500[1] | 213 | 189 | 245 | 254 | 345 | 622 | 215 |
| Total Hardness | mg/L | None | 131 | 120 | 167 | 124 | 160 | 61 | 139 |
| Alkalinity (Total) as $CaCO_3$ | mg/L | None | 127 | 144 | 191 | 180 | 279 | 147 | 142 |
| Calcium | mg/L | None | 31 | 30 | 37 | 38 | 31 | 16 | 26 |
| Magnesium | mg/L | None | 13 | 11 | 18 | 7 | 20 | 5 | 18 |
| Sodium | mg/L | None | 21 | 23 | 31 | 48 | 77 | 154 | 24 |
| Potassium | mg/L | None | 2 | 1.4 | 3.1 | 0.9 | 1.3 | 1.2 | 3.4 |
| Bicarbonate ($HCO_3$) | mg/L | None | 126 | 143 | 190 | 179 | 276 | 145 | 142 |
| Sulfate | mg/L | 250; 500; 600[2] | 23 | 5 | 10 | 20 | ND | ND | 22 |
| Chloride | mg/L | 250; 500; 600[2] | 13 | 11 | 17 | 14 | 19 | 176 | 17 |
| Fluoride[1] | mg/L | 2 | ND | 0.2 | 0.2 | 0.2 | 0.4 | **8.8** | ND |
| Nitrate as $NO_3$ | mg/L | 45 | 8.6 | ND | ND | ND | ND | ND | 0.4 |
| **Detected Inorganic Constituents (Trace Elements)[2]** | | | | | | | | | |
| Aluminum | μg/L | 200 (S); 1,000 | ND | ND | ND | ND | 654 | 58 | ND |
| Arsenic | μg/L | 10 (P) | ND | 1 | 2 | 7 | 5 | 6 | 5 |
| Barium | μg/L | 1000 (P) | ND | ND | ND | ND | 168 | ND | ND |
| Boron | μg/L | 1000 (NL) | ND | 100 | 200 | 300 | **1,200** | **4,700** | 100 |
| Bromide | μg/L | None | 60 | 60 | 80 | 70 | 120 | 520 | 80 |
| Chromium | μg/L | 50 (P) | ND | ND | ND | ND | 3 | ND | ND |
| Copper | μg/L | 1300 (RAL) | ND | ND | ND | ND | 1 | ND | ND |
| Iron | μg/L | 300 (S) | ND | ND | 6 | 41 | **868** | 84 | 6 |
| Lead | μg/L | 15 (RAL) | ND | ND | ND | ND | 2 | ND | ND |
| Manganese | μg/L | 50 (S) | ND | ND | 14 | **119** | **565** | **88** | **442** |
| Mercury | μg/L | 2 (P) | ND | ND | ND | ND | ND | 5 | ND |
| Nickel | μg/L | 100 (P) | ND | ND | ND | ND | 2 | ND | ND |
| Selenium | μg/L | 50 (P) | ND | ND | ND | ND | 1 | 2 | ND |
| Strontium | μg/L | None | 235 | 230 | 302 | 1,110 | 371 | 398 | 308 |
| Vanadium | μg/L | 50 (P) | ND | ND | ND | ND | 8 | ND | ND |

**NOTES:** Source of available water quality data: DWR Water Data Librarary (http://www.water.ca.gov/waterdatalibrary/)

(1) Turbidity was not reported on any of the availble water quality reports for these MCWA nested monitoring wells.

(2) The three listed numbers represent the recommended, upper and short-term Secondary Maximum Contaminant Levels for the constituent.

mg/L = milligrams per liter

μg/L = micrograms per liter

ND = Not Detected

(P) = Primary; (S) = Secondary

RAL = Regulatory Action Level

NL = State Notification Level